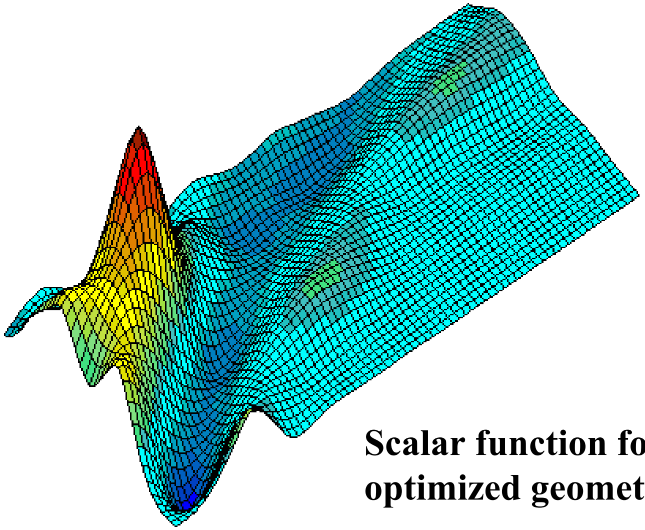
Numerical Methods for Evolving Topology

Robert Haber and Daniel Tortorelli, CPSD, University of Illinois
Martin Bendsøe, Technical University of Denmark DMR 01-21695

Research:

Some of the most challenging problems in computational science and engineering involve analysis domains with moving interfaces and variable connectivity. For example, simulations of microstructure evolution in solids must track large changes in particle geometry, including coalescence. We are developing new analysis techniques that loosely couple physical response models to implicit geometry models. This circumvents numerical problems, such as mesh tangling and errors associated with remeshing and projection. To illustrate, we consider a shape optimization problem inspired by the Swiss bridge designer, Robert Maillart.
We use radial basis functions to describe a surface whose zero-contour level determines the boundaries of the structural domain.

Robert Maillart's Salginatoble Bridge
Credit: Structurae (www.structurae.de)



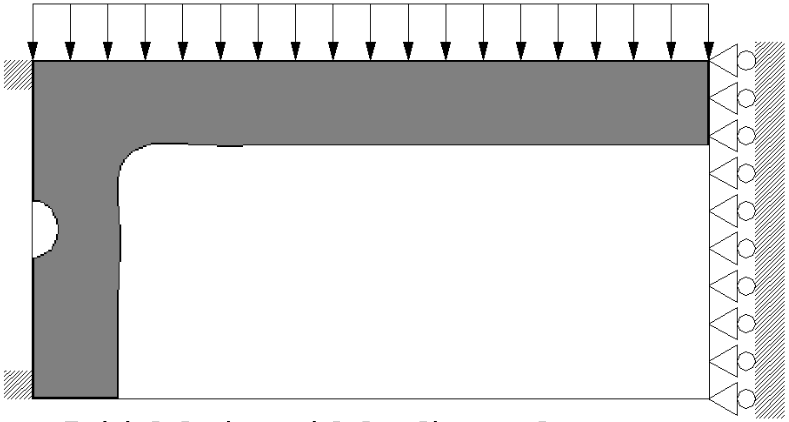
Scalar function for optimized geometry

Numerical Methods for Evolving Topology

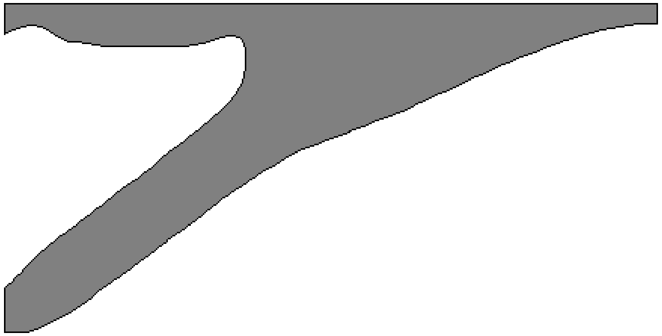
Robert Haber and Daniel Tortorelli, CPSD, University of Illinois
Martin Bendsøe, Technical University of Denmark DMR 01-21695

The implicit geometry model interacts with a fictitious–domain finite element model defined on an independent grid. Here we show results of a minimum–compliance shape optimization that are reminiscent of Maillart's elegant designs. The optimized design is the level set of the surface depicted on the previous slide.

Detail of Maillart's bridge. Credit: Structurae



Initial design with loading and support conditions (half structure)



Optimized design obtained with fictitious domain analysis method